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ETHOLOGY OF *NEOITAMUS VITTIPES* (DIPTERA: ASILIDAE) IN SOUTH AUSTRALIA[1,2]

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Abstract.—A field study of the predatory and mating behavior of *Neoitamus vittipes* (Macquart) is reported. Prey taken by *N. vittipes* represented five orders, the majority being in the order Diptera. Mating, without prior courtship, took place in a tail-to-tail position, mostly in the afternoon. Incidental data is included concerning distribution and predatory behavior of *Neoitamus armatus* (Macquart) and *N. margites* (Walker).

With the exception of the recent paper by Daniels (1976) on the predatory and courtship behavior of *Promachus interponens* Walker, nothing has been written of the behavior of Australian robber flies. Thus far, the majority of behavioral studies have been done on species in North America, Russia, and Europe.

Neoitamus vittipes (Macquart)

Published records of the occurrence of *Neoitamus vittipes* (Macquart) are few. The original type-series was collected in Tasmania, but the synonymy established by Hardy (1920) extended its distribution to continental Australia, with records from Victoria and New South Wales (January to March). While on sabbatical at the Waite Agricultural Research Institute (November 1978–May 1979), I collected *N. vittipes* at the following locations in South Australia: 2.6 km N of Port Wakefield (23.xi.78), 6 km SW of Virginia (23.xi.78), 4.5 km E of Keyneton (30.xi.78), 16 km N of Kingston (18–19.xii.78), ca. 12 km SE of Milang (20.xii.78, 1.iii.79), 3 km E of Milang (8.i.79, 2–3.iii.79), 8 km E of Milang (19.xii.78, 12.ii.79, 1.iii.79), 10 km S

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of Milang (20.xii.78), 11.6 km NW of Morgan (22–27.iii.79), 2.7 km S of Kapunda, bank of Light River (22.iii.79). Additionally, specimens in student collections provided records for Adelaide (early February 1979) and Port Gawler (16.ii.77, "flying around Melaleuca").

Typical habitats from which *N. vittipes* was collected included rocky hillside pastures dominated by *Avena barbata* Pott ex Link, dryland lucerne (alfalfa) fields, borders of irrigated lucerne fields, weedy borders of cropland, a weedy horse paddock and open rangeland dominated by *Maireana sedifolia* (F. Muell.) Wilson (bluebush) and *Danthonia* sp. (wallaby grass).

Most behavioral observations were made on a population inhabiting a field of irrigated lucerne 3 km east of Milang, S.A. This population was largely concentrated within the first 5 m of lucerne along the borders of the field, except where incursions of grass created clearings. The asilids would then be found foraging from individual plants bordering the clearings. The species was studied during the period March 5 to 13, 1979 at this site; a few additional observations were made December 18–19 in a dryland lucerne field opposite Coorong National Park, 16 km N of Kingston.

Methods

Approximately 100 localities in South Australia were surveyed during spring and summer of 1978–79 to ascertain the distribution and abundance of species of robber flies. An hour or two of walking through a particular habitat was usually sufficient to establish what species were present and their density. In disturbed habitats in South Australia, it was not uncommon to find only one species present, whereas many undisturbed areas, e.g., conservation parks, supported several species concurrently.

Once a suitably dense population of an asilid species was encountered, one or two observers visited the area on several successive days. In general two approaches were employed, (1) single flies were continuously observed for one to two hours each, and (2) the observer slowly traversed the area noting the activities of many different flies.

Constant and extended surveillance of individual flies yielded a mass of information concerned primarily with foraging and feeding, whereas surveying the area provided greater opportunity for observation of mating pairs and for locating ovipositing females.

Observations were recorded in notebooks on the study site. These included detailed records of foraging, feeding, mating, and oviposition, whenever observed. Times and when possible, durations of these activities were noted. Temperatures were taken from the soil surface or the height on the vegetation where the behavior was occurring. Permanent photographic records of each behavior were obtained using a Nikon 35 mm, single lens reflex camera with a Micro-Nikkor-P.C. Auto 1:3.5, 55 mm lens.

Recorded behavior patterns involving flight were defined as follows: (1) Foraging flights were those in which the individual flew towards a potential prey, regardless of whether it was successful; (2) investigatory flights where the asilid would fly towards a potential prey, but turn back without attempting capture (presumably, size or structural characteristics functioned to make the insect unsuitable); (3) manipulation flights (rotation flights of Scarbrough and Norden, 1977) in which an individual would fly briefly from a feeding site, manipulate prey, and return to the same or nearby perch; (4) orientation flights in which the asilid would move to a new location as a result of being shaded, disturbed, or not making visual contact with potential prey over a period of time (these flights were made slowly and usually covered only a short distance); (5) agonistic flights which involved aggressive encounters between males; and (6) searching flights which consisted of long, rapid, sometimes undulating flights taken by males in search of receptive females.

Prey was collected whenever possible. Either the robber flies observed feeding on prey were netted, the prey was collected, and the asilid was released unharmed, or the predator was observed until completion of feeding and the prey was recovered where it was dropped. The latter method, while supplying information on feeding times and manipulation behavior, sometimes resulted in the loss of prey, since asilids often dart after new prey, releasing the exhausted meal in flight. Occasionally, an insect net was placed carefully over the feeding asilid and held in place until completion of feeding. However, this method lacks desirability since a puff of wind striking the net may disturb the asilid, causing it to drop prey, which if tiny, may disappear among the surface debris.

Collected prey were placed in a 2 dram vial and subsequently measured for total body length to the nearest 0.5 mm, after which it was either mounted by pinning or placed in 70% ETOH. Similar measurements were made of the predator, i.e., 14 specimens of each sex. In this way, the predator to prey size ratio was obtained. An additional procedure, although not used in this study, is that of Scarbrough (1978), who oven-dried prey of selected lengths to obtain predator to prey weight ratios.

Prey were identified to order-family and then submitted to specialists for further identification (see Acknowledgments). The prey collection is housed at Waite Agricultural Research Institute in Adelaide, S.A.

Foraging and Feeding Behavior

Perch sites, from which *N. vittipes* launched attacks on potential prey, varied with the character of the habitat. In the population which inhabited the lucerne field, the majority of flies foraged from vegetation (lucerne, 62%; weeds, 16%; irrigation pipe, 6%; soil, 10% and grass stalks, 6%) throughout

Fig. 1. *Neoitamus vittipes* male feeding on the syrphid, *Simosyrphus grandicornis*, while holding onto lucerne leaves.

the day. However, in rocky pastures and dryland alfalfa fields, the majority of asilids launched attacks from the soil surface or from small rocks.

Exclusive of soil the heights on plants, where foraging individuals were observed, varied from 5 to 38 cm (mean 19.3 cm). When on soil, individuals were either resting broadside to the sun or facing directly into it, a behavior which is directly related to soil surface temperature in other asilid species (Lavigne and Holland, 1969; Dennis and Lavigne, 1975, 1979). These other asilids studied maintain temperature control through positional changes, utilizing soil in early morning, thereby increasing heat absorption, and vegetation around midday when soil temperatures are excessive. Presumably the Kingston population functioned in a similar manner.

While resting on foraging sites, the flies were largely quiescent, except when potential prey flew within their field of vision. The asilid would then turn its whole body to face the organism. One can assume that such postural changes increase range of vision and place the asilid in a suitable position to make a direct forage flight (Dennis and Lavigne, 1975).

All forage flights were directed at insects that were air borne. Distances covered in forage flights ranged from 7.6 to 71 cm (mean 25.6 cm). Flights which resulted in prey capture ranged in length from 7.6 to 45.7 cm (mean

Table 1. Relation between length of *Neoitamus vittipes* and that of its prey.

Sex	Predator Length (mm)[1]			Prey Length (mm)			No. Prey Measured	Mean Ratio of Predator: Prey
	Min.	Max.	Mean	Min.	Max.	Mean		
Male	10.0	13.0	11.6	1.0	9.0	3.7	12	3.1
Female	11.5	14.5	12.6	0.5	10.0	4.4	24	2.9
Combined	10.0	14.5	12.1	0.5	10.0	4.2	36	2.9

[1] 14 predators of each sex were measured from the Milang population.

21.4 cm), suggesting that as distance increases between predator and potential prey, the asilids decrease in capture efficiency.

Most flights initiated in pursuit of prey were unsuccessful. Based on a limited number of observations, prey capture efficiency for *N. vittipes* is poor, i.e., 16%. On two occasions (one male, one female) flights were directed towards cruising honeybees. In both instances, the asilid turned away and returned to the foraging site, after covering ⅓ to ½ of the distance. These investigatory flights undoubtedly maximize net energy gain, i.e., lower pursuit costs since the asilid does not chase prey that is likely to escape.

Once prey were captured, the asilid hovered briefly, manipulated the prey using all six tarsi and impaled it prior to landing.

During the feeding sequence, most prey were manipulated one or more times. The prey were manipulated with all six tarsi, during a short flight 1–2 cm away from the feeding site. Manipulation, while hovering is typical of the behavior of Asilinae in North America (Dennis and Lavigne, 1975, 1979; Lavigne, 1979; Lavigne et al., 1976; Lavigne and Dennis, 1980).

Once feeding is completed, the chitinous exoskeleton of the prey is pushed off the proboscis by the asilid's foretarsi on the feeding site.

Only twice were complete feedings monitored. In one instance a female fed upon a bushfly, *Musca vetustissima* Walker, for 25 minutes. A second case involved a male, which fed upon the syrphid, *Simosyrphus grandicornis* (Macquart), for a period of 2 hours and 10 minutes (Fig. 1).

One case of cannibalism was observed in the population 16 km N of Kingston. In this instance a male attacked and killed a second smaller male (Fig. 2). During the initial struggle, the larger male lay on its side on the ground manipulating the other male with all six tarsi, a technique apparently forced on it by the large size of the prey.

Based on 36 measured prey of *N. vittipes*, the "preferred" prey length was 4.3 mm, although the size of prey taken varied from 0.5 to 10.0 mm (Table 1). Females were slightly larger than males (12.6 vs. 11.6 mm) and tended to capture slightly larger prey (4.4 vs. 3.7 mm). Males concentrated

Table 2. Comparison of prey items taken by three species of *Neoitamus* in various parts of the world.

	N. vittipes (Australia)		*N. angusticornis* (Japan)[1]		*N. cyanurus* (England)[2]	
Order	No.	%	No.	%	No.	%
Araneae			3	2.8		
Coleoptera			15	14.2	9	14.0
Diptera	28	73.8	58	54.8	38	59.3
Ephemeroptera			3	2.8		
Heteroptera	2	5.2			3	4.7
Homoptera	4	10.6	4	3.8		
Hymenoptera	2	5.2	12	11.3	1	1.6
Isoptera			1	0.9		
Lepidoptera	2	5.2	9	8.5	11	17.2
Neuroptera			1	0.9	1	1.6
Odonata					1	1.6
Totals	38	100	106	100	64	100

[1] Records of prey collected by Iwata and Nagatomi (1962).
[2] Compilation of prey records collected by Hobby (1931, 1933, 1934), and Poulton (1907).

on Diptera (90%) and only incidentally took Hemiptera (10%). Females, while concentrating on Diptera (65%), fed on representatives of four other orders, Hemiptera (3.9%), Homoptera (15.5%), Hymenoptera (7.8%) and Lepidoptera (7.8%). The mean predator to prey length ratio for this species was 2.9 (Table 1).

Various authors (Bromley, 1945; Crowhurst, 1969; Fattig, 1945; Melin, 1923; Myers, 1928; Valentine, 1967) have recorded occasional instances of predation by members of the genus *Neoitamus*. However, for only two species, *N. angusticornis* Loew and *N. cyanurus* Loew, are there sufficient data for a prey selection comparison. As can be seen in Table 2, the tendency of *N. vittipes* to selectively choose Diptera over other available insects in the habitat is shared by these two other species in widely separated parts of the world.

In addition to the records for *N. cyanurus* presented in Table 2, Melin (1923) noted Diptera and Lepidoptera as prey in Sweden. Diptera also were recorded as the most common prey in Romania (Ionescu and Weinberg, 1960) and in England by Parmenter (1952). Attwood (1937), although not collecting prey, noted that *N. cyanurus* took large numbers of *Tortrix viridana* L. (Lepidoptera: Tortricidae.)

Herein is a list of prey taken by *N. vittipes*. Specific identifications were made, where possible, but because of the state of knowledge in some groups, only genus and/or family are included for some specimens. The

Fig. 2. A case of cannibalism in which one *Neoitamus vittipes* male has captured and is feeding on another male of the same species.

number of records and sex of the predator are indicated in parenthesis following the prey record.

DIPTERA, Anthomyiidae: *Hylemyia deceptiva* Malloch, 7.iii.79 (♀); Asilidae: *Neoitamus vittipes* (Macquart), 18.xii.78 (♂); Chironomidae: *Pentaneura levidensis* (Skuse), 6.iii.79 (♂); *Procladius paludicola* Skuse, 6.iii.79 (♂), 7.iii.79 (♂); Choloropidae: indet. A, 6.iii.79 (♀); *Lioscinella* sp., 6.iii.79 (♀); Ephydridae: indet., 8.iii.79 (♀); Lauxaniidae: *Poecilohetaerus schineri* Hendel, 9.iii.79 (2 ♀); Muscidae: *Atherigona* sp. A, 7.iii.79 (2 ♀); *Coenosia acuticornis* Stein, 7.iii.79 (♀), 9.iii.79 (♂); *Musca vetustissima* Walker, 19.xii.78 (♂, 2 ♀), 6.iii.79 (♀); Phoridae: *Megaselia* sp., 6.iii.79 (♀); Sepsidae: *Lasionemapoda hirsuta* (de Meij.), 9.iii.79 (♀), Syrphidae: *Melangyna collata* (Walker), 5.iii.79 (♀), 7.iii.79 (♀), 9.iii.79 (♀); *Simosyrphus grandicornis* (Macquart), 6.iii.79 (♂). HEMIPTERA-HETEROPTERA, Lygaeidae: *Nysius vinitor* Bergr., 5.iii.79 (♂), Miridae: *Campylomma lividum* Reuter, 8.iii.79. HEMIPTERA-HOMOPTERA, Aphididae: indet. winged reproductive, 7.iii.79 (♀); Cicadellidae: indet., 7.iii.79 (♂). HYMENOPTERA, Braconidae: Aphidiinae, indet., 8.iii.79 (♂); Ichneumonidae: *Diplaxon* sp., 7.iii.79 (♀). LEPIDOPTERA, Lycaenidae: *Zizina labradus labradus* (Godart), 7.iii.79 (2 ♀). An additional two Diptera and three Homoptera remain unidentified.

Mating

As with other species of Asilinae studied, there is no courtship by males. It is probable that encounters between males and females resulted from searching flights of males, although such data were not collected. This strategy is used by many species of Asilini.

Upon observing a female, the male launches itself towards her, catching her in flight. Copulation takes place prior to landing, in the male atop female position. Approximately five seconds after landing, the pair take a tail-to-tail position which is maintained throughout the copulation period (Fig. 3). The male rotates his abdomen 70–90° at intermittent intervals which causes the female's abdomen to be extended, curved and pulled towards the male. Rotations occur at a rate of ca. 1/s in a short series, followed by periods of rest. As the mating progresses, the rate of rotation increases to ca. 2/s. The male's wings remain folded over his dorsum throughout mating, being flicked open occasionally, while the female's wings remain slightly open. Separation occurs when the male releases his claspers. Both either fly off immediately or rest for short periods of time, and then fly.

Mated pairs were observed on vegetation (grass stalks and lucerne) at heights ranging from 2.5 to 35 cm (mean 22 cm). Temperatures at these heights ranged from 22 to 34°C (mean 26.9°C). Additionally, three mated pairs were encountered resting on soil (surface temperature 26–28°C) at the site north of Kingston. Pairs were observed in copula as early as 9:37 AM and as late as 3:58 PM, with all but one occurring after 12 noon. Total time in copula for two observed complete matings (i.e., initial contact to separation) was 21 and 33 minutes.

Oviposition

According to Melin (1923), female *Neoitamus cyanurus* deposits its eggs in "closed top buds," in "small round strobiles," and in the apices of boughs of alder from which the species also forages. The elongate, laterally compressed ovipositor is highly suitable for this task.

The ovipositor of *N. vittipes* is similarly laterally compressed suggesting that this species also oviposits in suitable locations on vegetation. On one occasion, the author observed a female probing with its ovipositor, in the manner described for *Machimus callidus* (Williston) (Dennis and Lavigne, 1975). The ovipositor was moved from side to side at the tips of lucerne leaves and inserted within folded unopened leaves at heights of 20 to 36 cm. No eggs were found, however, when these sites were examined. Whether or not such sites are utilized is probably immaterial since the lucerne was cut two days later. It is much more probable, since the species has survived in this field as well as along the margins of several other lucerne fields in

Fig. 3. Mating pair of *Neoitamus vittipes* resting on vegetation in a field of lucerne.

the vicinity, that oviposition sites are grasses or weeds. Certainly, such sites suffice for some other Asilini (Dennis and Lavigne, 1979).

Neoitamus armatus (Macquart)

Occasional specimens of this species were collected at two locations in South Australia in areas containing native vegetation, Aldinga Beach and The Ferries-McDonald Conservation Park, south of Monarto. The species was collected during the period December 11th to January 31st. Hardy (1920) recorded this species in New South Wales and Tasmania, from October to January and April.

Specimens were observed foraging from branches of malee at heights up to 1.7 m. It was also observed resting on fallen branches while feeding on prey. Prey of one male in the Aldinga Beach scrub community was an unidentified tiphiid wasp (Hymenoptera), while a female captured a specimen of *Anthrenocerus australis* Hope (Coleoptera: Dermestidae). A male at Ferries-McDonald Conservation Park was photographed while feeding on *Nysius vinitor* Bergr. (Hemiptera: Lygaeidae).

Neoitamus margites (Walker)

South Australian collection records for this species are as follows: Mortlock Experiment Station, Auburn (17.i.79, 24.i.79), Ferries-McDonald Conservation Park, S of Monarto (11.xii.78), 3.3 km S of Echunga (1.iii.79), and

8 km ENE of Callington (21.xi.78). *Neoitamus margites* had previously been recorded from Tasmania and New South Wales by Hardy (1920). Habitats, in which this species was found were dominated by *Eucalpytus* sp. with an understory of *Avena barbata* or native vegetation, e.g., horse paddocks and conservation areas.

Foraging flights were initiated from the soil surface, from fallen *Eucalyptus* branches and from the trunks of gum trees. Flights were at heights of 25–50 mm over distances of 0.15 to 0.3 m. The only prey observed being taken were four specimens of unidentified winged reproductive ants at Mortlock Experiment Station.

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